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Industrial arts project evaluation guide based on quality control principles and processes used in industry

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INDUSTRIAL ARTS PROJECT EVALUATION GUIDE BASED ON QUALITY CONTROL PRINCIPLES AND PROCESSES USED IN INDUSTRY

by

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Signatures have been redacted for privacy

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I. INTRODUCTION

A. Why is Project Construction Used as a Teaching Method in Industrial Education

Project oriented activity is generally recognized as an important part of the total learning process in industrial education. Since project construction itself is the practice and application of scientific principles and theory, project learning in the industrial arts program becomes unique in educating both the mental and physical. Oscar L. McMurry, (7, page 110) an early author in industrial education, says:

> "Such a complete object is a realized thought and suggests an entire process of mental and physical effort combined into a practical intelligence in dealing with a real problem. It furnishes, therefore, a sound basis for determining a rational method of dealing with constructive problems. Herein lies a distinctive advantage in the industrial arts; namely complete objective constructive projects, determining beforehand a sound method for class instruction in shop exercises."

Moreover, project construction in the industrial arts laboratory provides students with an exploratory experience in problem solving. It is through the industrial arts activities that many students first learn to understand the value of work by actual participation in planning, designing, and actual construction. Oscar L. McMurry (7, page 110) also points out the significance of this activity:

> "In view of the striking objectivity of their projects and of the progressive, problem solving character of their constructions, the industrial arts seem to surpass all other school studies in demonstrating, in objective, elaborate detail, the essential process of classroom instruction."

The statement above is indicative of the contemporary thoughts of many educators concerning the value of project construction as an integral part of the industrial arts program. However, despite the recognition of the contribution this activity makes, one of the major problems for all industrial arts teachers is the evaluation of the student's project with respect to fairness and objectivity. The commonly used method of project evaluation is based solely on the teacher's judgment of the student's finished project.

The weakness in this method is that it disregards the importance of learning as a continuous process. Also, the value judgment of the student's progress and improvement throughout the entire project construction period will not be reflected in the evaluation of the end product. Thus, evaluation of the end product does not necessarily evaluate many of the learning experiences which went into earlier stages of construction. Laurence V. Calvin (2, pages 14-15), supervisory critic of Ohio State University, said:

> "Too much emphasis is being placed on the finished product, therefore making it the end rather than the means to an end."

B. Statement of the Problem

Project evaluation is traditionally a quality appraisal and judgment to rate the student's finished product; such as the quality of finish, overall appearance and measurement. However, finished product quality is only the end result of many educational activities occuring earlier in its construction processes. Those factors determining the outcome of the end product include the design, function, precision, measurement, finish ... and many other factors as judged by quality control processes in industry. The industrial arts project learning is a simulation of the industrial processes and production, and thus should also be subject to evaluation according to quality control principles and processes used by industry.

C. Basic Assumptions

1. Learning is a continuous process of knowledge and skill development. Project construction is a phase of the learning process in the industrial arts total curriculum. Therefore, the evaluation of the student's progress should also be a continuous one instead of evaluating the student's end product alone.
2. Project learning in industrial education is geared to the application of scientific principles and theory, the understanding of industry, industrial processes and materials. Hence, it is assumed that project evaluation should parallel the scientific industrial practice in order to be meaningful.

D. Purposes of the Study

This study attempts to bridge the evaluation gap between project initiation and product completion, and thus to make project evaluation a continuous process. Further, such evaluation can become a part of the student learning activity toward the better understanding of industrial processes and materials through the use of industrial terminology and procedures. In addition, the student would be enabled to participate to a greater extent in his own grading.

Thus, grading would no longer be terminal in nature; neither is it solely a teacher's task to rank his students. Rather, this approach takes the form of a continuous, constructive measure of the student's learning progress and achievement.

It is the writer's opinion that this problem can be solved by incorporating the values of quality control principles and processes to further the evaluating process. In essence, the purposes of this study are:

1. To identify quality control principles and processes.
2. To discover the factors involved in the ultimate development of a quality industrial product based upon quality control principles and processes.
3. To develop an instrument, based upon quality control principles, processes, and procedures, whereby industrial arts teachers and students can evaluate the quality of processing which contributes to the quality of the finished product in the student's project learning activity.

II. BACKGROUND OF STUDY AND REVIEW OF LITERATURE

A. Philosophy and Objectives of Industrial Education

The old concept that industrial arts is the playground for manual training and for the lower I. Q., or the mentally retarded students, is dying. Roy W. Roberts (12, page 28), Department Head of Vocational Teacher Education of University of Arkansas, says:

> "Industrial arts is not confined to shop work nor is it designed for slow learners who cannot succeed in the academic curriculum."

The statement above is indicative of a majority of contemporary educators' views toward industrial education. The importance of industrial arts as an integral and essential part of general education is further clearly pointed out by professor Delmar W. Olson (10, pages 24-25) of Kent State University, Ohio:

> "And since industrial arts is general education, and its subject matter being technical, it is assumed that it is the responsibility of industrial arts to acquaint the young, both boys and girls, with the nature of technological culture. This industrial arts then, because of its primacy, becomes fundamental education in the American school. With its own body of subject matter, it assumes the role of a discipline in modern education."

The importance of industrial arts is recognized from the above statement. However, the significance of industrial arts, and its contribution towards general education is better understood by examining the industrial arts program activities. Again, Delmar W. Olson (10, page 25) defines industrial arts:

> "Industrial arts is a study of technology: its origins, developments, and advance; its technical, social, economic, occupational, cultural, and recreational nature and influences; through

> study, research, experiment, design, invention, construction, and operation with industrial materials, processes, products and energies; for purposes of acquainting the student with the technological culture and aiding him in the discovery and development, release and realization of his own native potential therein."

The contemporary philosophy and objectives of industrial education place emphasis on pupil interest, exploration, problem solving, planning, understanding of industrial processes and materials, home maintenance, and consumer value. Roy W. Roberts (12, pages 424-425) lists nine major objectives of industrial arts:

> "1. Interest in industry. To develop in each pupil an active interest in industrial life and in the methods and problems of production and exchange.
>
> 2. Appreciation and use. To develop in each pupil the appreciation of good design, materials and workmanship, and the ability to select, care for, and use industrial products wisely.
>
> 3. Self realization and initiative. To develop in each pupil the habits of self reliance and resourcefulness in meeting practical problems.
>
> 4. Cooperative attitudes. To develop in each pupil the readiness to assist others and to join in socially accepted group understandings.
>
> 5. Health and safety. To develop in each pupil desirable attitudes and practices with respect to health and safety.
>
> 6. Interest in achievement. To develop in each pupil a feeling of pride in his ability to do useful things and to develop certain worthy free time interests particularly in the crafts.
>
> 7. Habit of orderly performance. To develop in each pupil the habit of an orderly and efficient performance of any task.

8. Drawings and design. To develop in each pupil an understanding of all kinds of common graphic representations and the ability to express ideas by means of drawings and sketches.

9. Shop skill and knowledge. To develop in each pupil skill in the use of common tools and machines and an understanding of the problems involved in common types of construction and repair."

B. Project Construction Method as a Phase of Learning

In order to achieve the above mentioned objectives, industrial arts teachers have chosen the project learning activity as an important phase to supplement other classroom instructions. The theory of learning upon which such selection is based, though diversified, is by no means incomprehensible. The old Chinese philosophy, (If I hear, I don't remember, If I see, I forget, If I do, I know), bears the same philosophy as John Dewey's "learning by doing" theory.

In an attempt to clarify the relationship between teaching and learning, Gerald B. Leighbody, (6, page 1) pointed out clearly the functional activities of industrial arts in relation to student learning:

> "One of the first things to realize concerning this is that the teacher cannot give the learner any skill or knowledge by simply presenting this skill or knowledge to the pupil. It is not a matter of transferring what the teacher knows into the hands or minds of his pupils. The one who is to learn must pass through some active experience which will change his way of thinking or acting. He must do something in which his mind or muscles will take on new ways of behaving. He must not only receive new ideas or skills from the teacher by observing and listening, but he must attempt to use these

> skills and ideas himself. It is only when the pupil is engaged in putting into practice what he has seen, heard, or read that the learning process becomes complete."

The industrial arts project learning activity provides an excellent opportunity for the students to learn and experiment. The trend of industrial education is more closely to the child-centered development, learning through experimentation, exploration and creativities. Students are no longer confined to the classroom instructions; they are urged to learn through private research, library resource materials, laboratory experiments and consultation with other teachers, engineers and industrial experts. More and more emphasis is being focused on self development and learning through individualized instruction.

Since industrial arts project learning activity provides a variety of experience for the students, the industrial arts laboratory becomes the ideal place to begin individualized instruction. The industrial arts laboratory is not only a place for students to work, but is a learning laboratory similar to the physics or engineering laboratories.

Yet, like all learning activities, there are many problems which have to be solved, including industrial arts project learning and evaluation. It is our duty as industrial arts educators to solve these problems and to improve the learning situations. Professor Victor H. Noll (9, page 11) of Michigan State University comments on the difficulties of educational evaluation and measurement:

> "Many difficulties in educational measurement have already been overcome, and new progress is being made every day. Those obstacles and imperfections that remain should be regarded as a great challenge to the ingenuity, resourcefulness, and competence of those who work in this field."

C. The Problem of Evaluation and Grading

Since all learning activities have to be evaluated and graded, including industrial arts project learning activity, there should be some bases or criteria whereby industrial arts teachers can go by; whereas student's progress of learning can be judged fairly and objectively. Moreover, it will benefit the student's learning improvement. Because industrial arts project learning has abandoned the duplication approach of a predetermined assignment by the teacher, project construction has taken on a new form of learning. It is now a student assigned, self-motivated and individualized activity, with the teacher as a supervisor. Thus, various methods for project evaluation have also been experimented.

Michael Jankowski (4, pages 108-109) reported some success in a student jury grading system, in which he commented the result of his finding:

> "Strange enough, the student juryman judging his own project will be harder on himself than one would expect."

His statement was also confirmed by Donald Martin[a] on his own experiment

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[a] Interview with Donald Martin, private conversation on April 10, 1968, at the Industrial Education Department, Iowa State University, Ames, Iowa.

in his class in the industrial education department at Iowa State University. This also leads to the writer's idea for finding a project evaluation system whereby the student would participate in his own grading.

D. Purposes of Project Evaluation

The specific purposes of project evaluation are to show whether certain demonstrations should be repeated or improved, to indicate the needs of students in certain areas of understanding, to serve as a guide for student progress, and to reflect the instructor's teaching methods and materials. Louis V. Newkirk (8, pages 29-30) included six purposes for evaluation in industrial education. They are: (1) give educational guidance, (2) evaluate personality traits, (3) motivate learning, (4) study the effectiveness of teaching materials and methods, (5) measure student progress, and (6) diagnosis of pupil difficulties.

E. Project Evaluation by Quality Control Principles and Processes

The concept of industrial arts project evaluation based upon quality control principles and processes comes from the principal objective of industrial arts - namely, the understanding of industrial processes and materials.

However, Harold T. Amrine's (1, page 277) definition of "quality" is most commonly accepted and is as follows:

> "Quality begins with design, design specification, measurement standards, selection of manufacturing processes, tools, performance of necessary operation, and inspection in conformance with specification."

The term "control" refers to the act of direction, influence, restrain, command, verification, correction, and the cause or determination of a resulting phenomenon as described by J. M. Juran, L. A. Seder, and F. M. Gryna, Jr. (5, pages 4-5).

Quality control should not be confused with inspection. Richard J. Hopeman (3, page 434) says:

> "A distinction was made between inspection and quality control. It was noted that inspection involves checking to see if a product meets or does not meet a stated standard. The results of the inspection process are acceptance or rejection of the products. Quality control as distinguished from inspection is directed towards future production rather than past production. In quality control, the emphasis is placed on taking action in order that products will meet specification. Some of the methods for accomplishing this include the following
>
> 1. Adjusting machines when they are getting out of adjustment.
> 2. Evaluating of raw materials and supplies to see if they are causing defective quality in the product.
> 3. Correcting improper worker performance.
> 4. Correcting tool alignment and replacing worn tools.
> 5. Advising engineering and sales that product specifications be changed to conform to production capacities."

In the manufacturing process in a company, quality control is a system, a plan or method of approach to the solution of quality problems. In its broadest functional sense, quality control is the totality of activities which must be carried out to achieve the quality objectives of a company.

By the same token, an industrial arts student when constructing his project in the industrial arts laboratory, is learning the same processes and approaches the same methods to the solutions of a quality product. The only difference between the industry and the industrial arts laboratory is that the student's activity encompasses all phases of work, while in the industry, works are divided up into departments, simplified, and manned by different personnel. Yet the objectives are synonymous - to produce a quality product.

However, the outcome of a quality product is determined by many quality characteristics. J. M. Juran (5, page 5) called these characteristics as the make up ingredients of a quality atom:

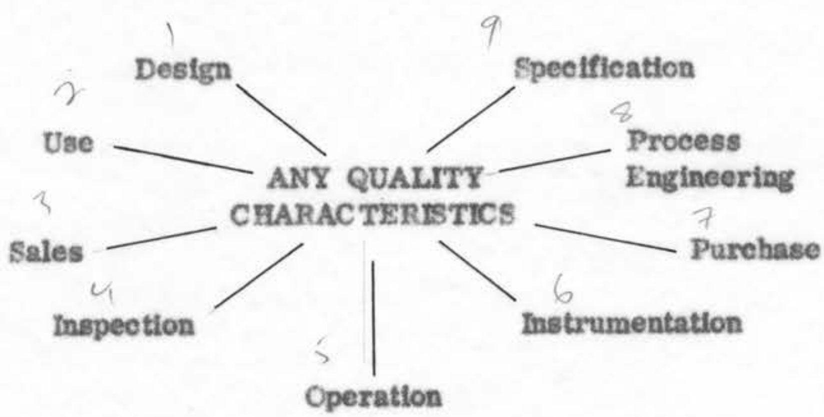

Figure 1. The quality atom

Other factors involved in the quality development include the appearance, life expectance, durability, dependability, reliability, maintainability, taste, and many other factors.

Thus, the evaluation of the student project should follow the same ideas in order to make the learning meaningful.

III. INVESTIGATION

A. Methods and Procedures

1. Survey of industry

A survey of industry was designed to discover the actual practice of industries in regard to quality control principles, methods and procedures, and to determine the importance of those factors that contribute to the outcome of a quality product.

A questionnaire was developed, then mailed to selected industries on April 22, 1968. The companies surveyed were chosen by the number of their employees. The wood, mechanical, and electrical industries, of which the company size was 100 employees or more were chosen. The data concerning these companies were gathered from the Directory of Iowa Manufacturers, sixth edition, 1965. The survey was also limited to the above mentioned companies whose plant location was in the state of Iowa. A total of 94 companies were surveyed; 29 were electrical industries, 60 were mechanical industries, and five were wood industries.

A letter of transmittal accompanied each questionnaire that was mailed. Fifty seven questionnaires were returned after three weeks. A follow-up letter was then mailed to those companies that did not reply to the first questionnaire.

The final return of this questionnaire survey was 63 or 67 percent. The breakdown of the questionnaires returned were as follows: 38 came from the mechanical classification, 25 came from the electrical classification, none of the five wood companies replied, and three of the returned questionnaires were not usable.

2. The student survey

A student survey was designed to discover the extent to which the students think they should participate in their own grading.

A student survey was conducted at the industrial education department of Iowa State University, Ames, Iowa. A total of 130 students were surveyed; of which 19 were graduate students, 21 were senior students, 32 were junior students, 38 were sophomore students, and 20 were freshman students. All 130 students tested were industrial education majors. The undergraduate students surveyed were taking safety education classes. The reason for this selection was that the total number of students in these classes covered the majority of students majoring in industrial education (111 out of 164, or 70 percent) at Iowa State University, Ames, Iowa. The graduate students surveyed were those taking I. Ed. 652, Evaluation of Industrial Education.

3. The survey of industrial arts teachers

This survey was designed to check the value of each item in the evaluation instrument, a developed rating scale based upon quality control principles and processes.

This final instrument was checked by 32 experienced industrial arts teachers who were participating in the industrial education summer program at Iowa State University, Ames, Iowa. Among these 32 industrial arts educators, four were doctoral candidates and had many years of both teaching and industrial experiences; three were associate professors in industrial education with more than five years of both teaching and industrial experiences. The remainder were industrial arts teachers in high schools with various lengths of both teaching and industrial experiences.

4. The statistical analysis

The statistical analysis was designed to discover if there was any significant differences in the means of those answers to each of those factors surveyed between the electrical and mechanical industries.

The analysis of variance, single classification, by size and by classification of industries was chosen for this problem analysis. The data was first tabulated, then coded and computer analyzed.

B. Delimitation of Investigation

1. The survey of industry was limited to the wood, electrical, and mechanical industries, with a company size of 100 employees or more, and which were located in the state of Iowa.

2. The student survey was limited to the industrial education majors at Iowa State University, Ames, Iowa.

3. Interviews of industrial arts instructors, engineers, and statistics consultants were limited to the personnel from Iowa State University, Ames, Iowa.

IV. FINDINGS

A. The Survey of Industry

There were four questions involved in the mailed questionnaire (see Appendix, page 55). The first one was to determine the important factors involved in the design and specification of a quality product. The second question was used to determine the extent to which industries practice the methods of quality control. The third question was used to determine the actual industrial practice of quality control principles. The fourth question was used to discover other additional factors involved in the development of a quality product by industries. Figure 2 and Figure 3 indicate the response to questions one and two by the mechanical industry whose company size was 100–500 employees. Figure 4 and Figure 5 show the responses to questions one and two by the mechanical industries whose company size was 500 employees or more. Figure 6 and Figure 7 show the responses to questions one and two by the electrical industries whose company size was 100–500 employees. Figure 8 and Figure 9 show the responses to questions one and two by the electrical industries whose company size was 500 employees or more.

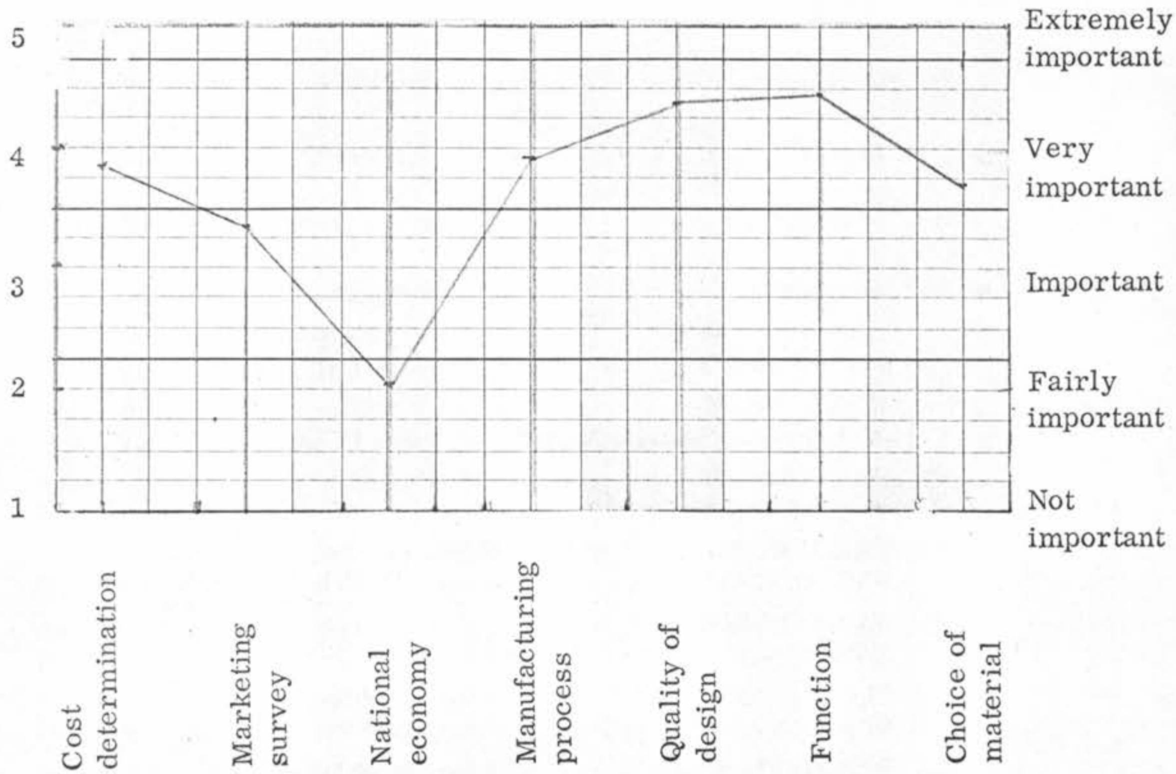

Figure 2. Importance rating of the design and specification criteria of a quality product by Iowa mechanical industries (company size: 100-500 employees)

Figure 2 indicated the average opinion on the importance of those factors which determine the quality of a product from the Iowa mechanical industries (company size: 100-500 employees). The quality of design and function were the extremely important factors. The cost determination, manufacturing process, and choice of material were the second most important factors. The marketing survey was the third most important factor. The national economy was the least important factor when compared to the others, in determination of a quality product.

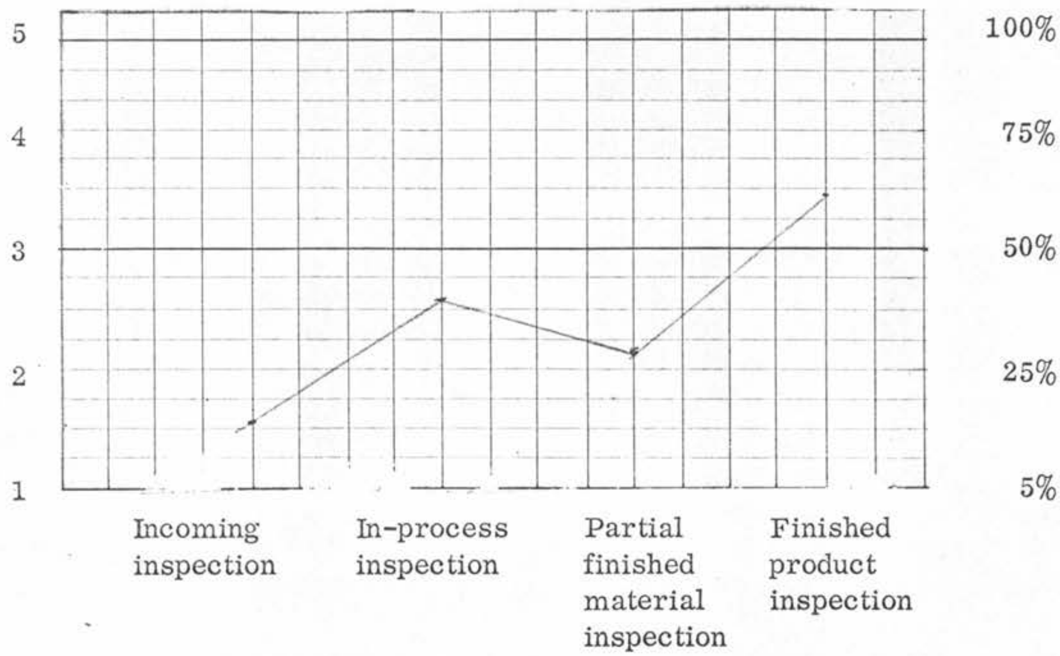

Figure 3. Average practice of quality control methods used by Iowa mechanical industries (company size: 100-500 employees)

Figure 3 indicated the average practice of quality control methods by the Iowa mechanical industries (company size: 100-500 employees). The finished product inspection was practiced at the 75 percent level by 86 percent of the companies. The in-process inspection was practiced at the 50 percent level by 87 percent of the companies. The partial finished material inspection was practiced at the 50 percent level by 76 percent of the companies. The incoming material inspection was used at the 25 percent level by 80 percent of the companies.

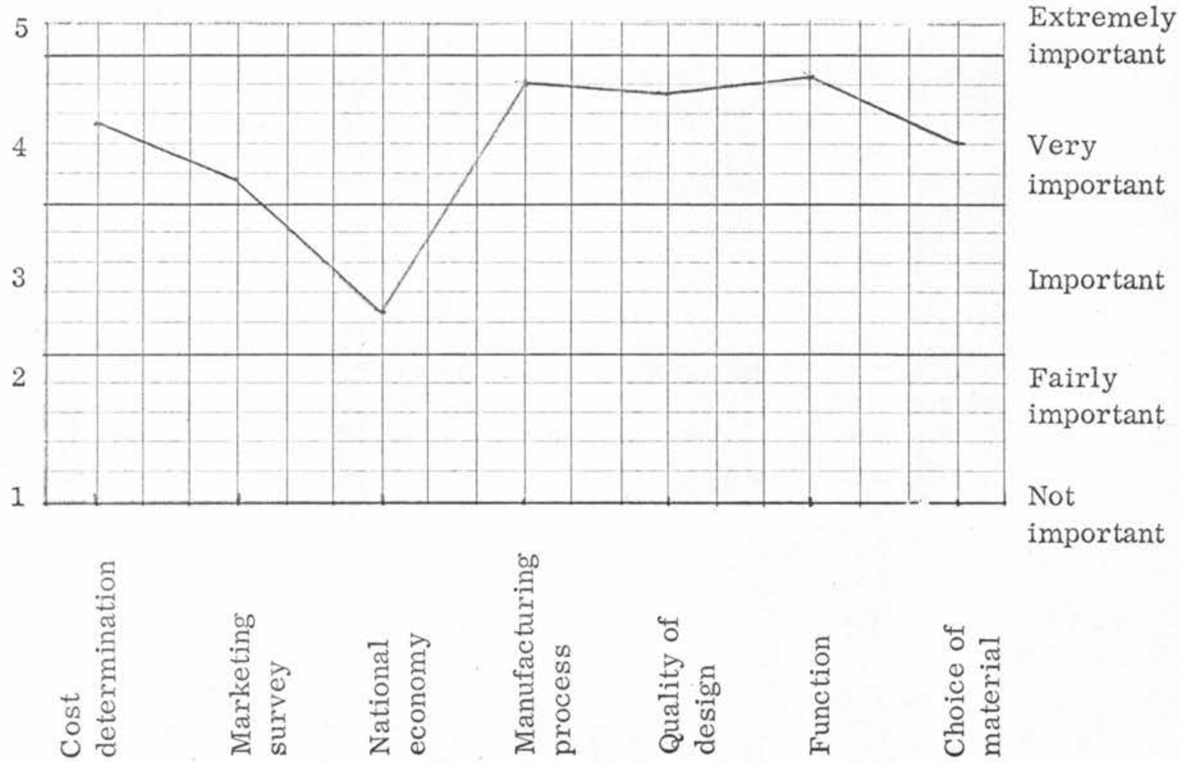

Figure 4. Importance rating of the design and specification criteria of a quality product by Iowa mechanical industries (company size: 500 employees or more)

Figure 4 indicated the average opinion on the importance of those factors which determine the quality of a product from the Iowa mechanical industry (company size: 500 employees or more). The manufacturing process, function, and quality of design were the extremely important factors. The cost determination and choice of material were the second most important factors. The marketing survey was the third most important factor. The national economy was the least important factor when compared to the other factors in determination of a quality product.

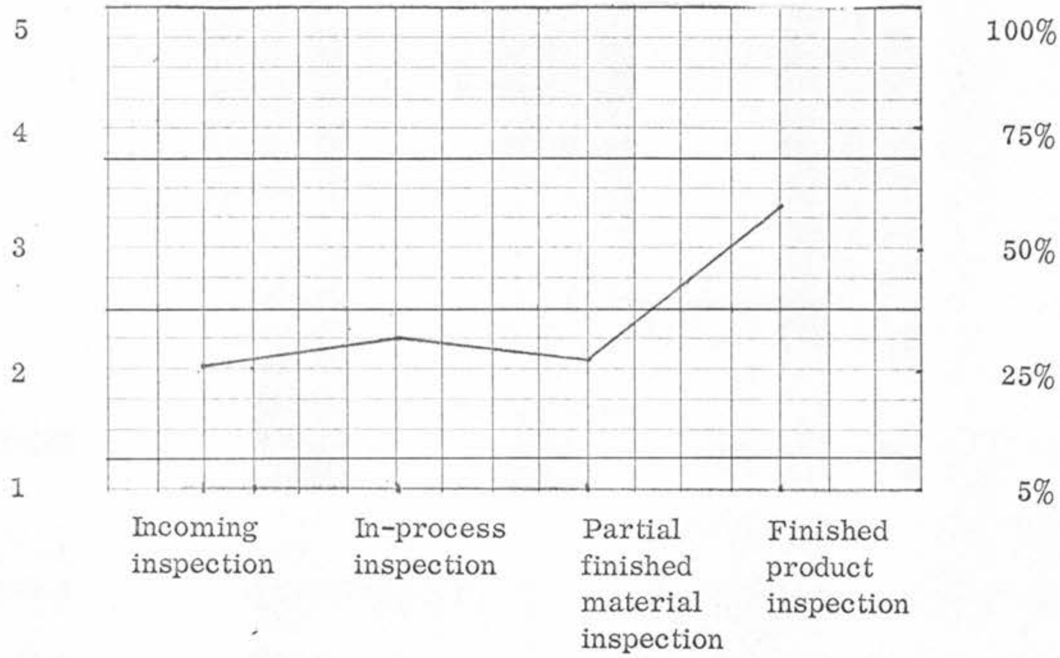

Figure 5. Average practice of quality control methods used by Iowa mechanical industries (company size: 500 employees or more)

Figure 5 indicated the average practice of quality control methods by the Iowa mechanical industries (company size: 500 employees or more). The finished product inspection was used at the 75 percent level by 86 percent of the companies. The in-process inspection was used at the 50 percent level by 75 percent of the companies. The partial finished product inspection was used in the lower 50 percent level by 71 percent of the companies. The incoming material inspection was used at the 25 percent level by 67 percent of the companies.

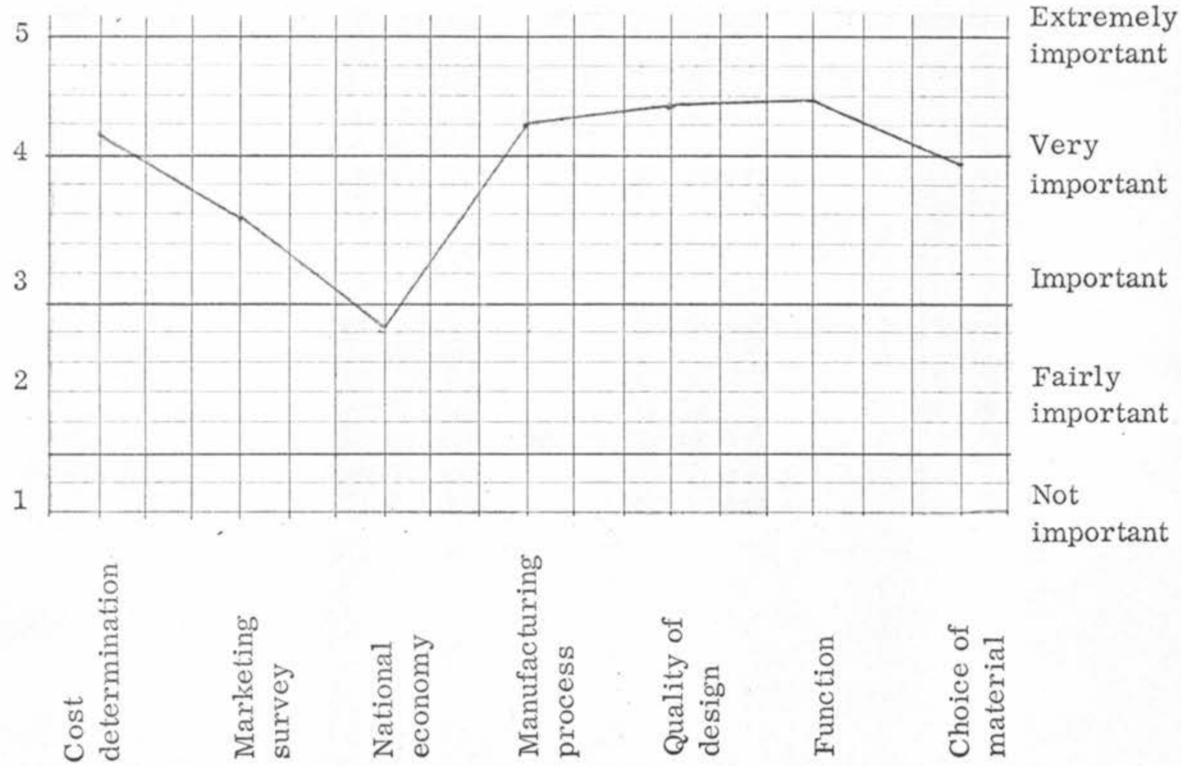

Figure 6. Importance rating of the design and specification criteria of a quality product by Iowa electrical industries (company size: 100-500 employees)

Figure 6 indicated the average opinion on the importance of those factors which determine the quality of a product from the Iowa electrical industries (company size: 100-500 employees). The function, quality of design, and manufacturing process were considered the extremely important factors. The cost determination and choice of material were the second most important factors. The marketing survey was the third most important factor. The national economy was the least important factor when compared to the others in determination of a quality product.

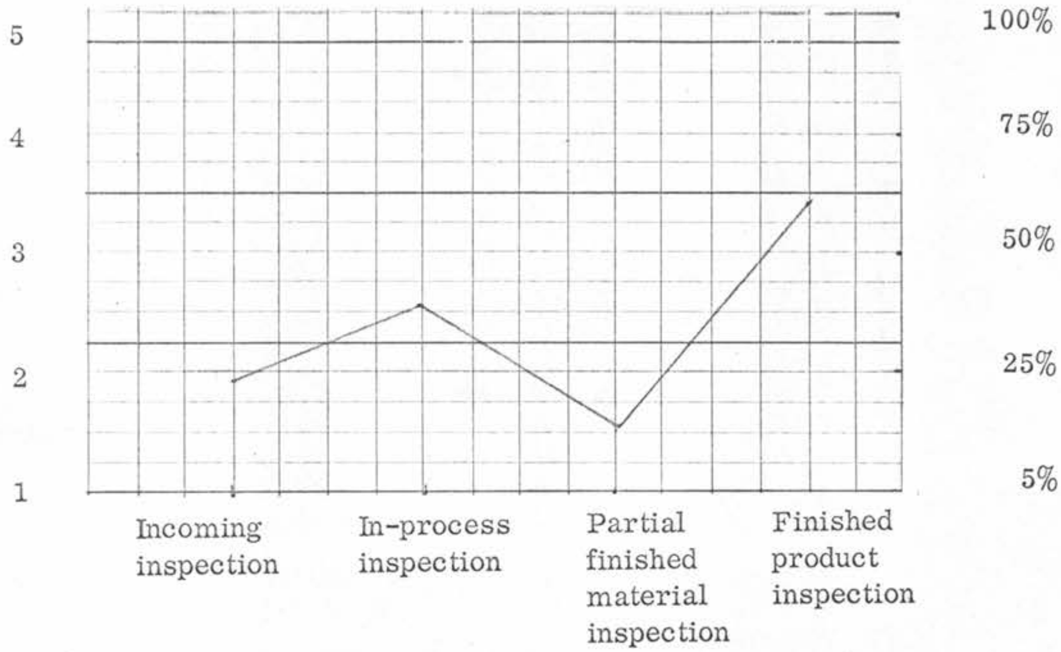

Figure 7. Average practice of quality control methods used by Iowa electrical industries (company size: 100-500 employees)

Figure 7 indicated the average practice of quality control methods by the Iowa electrical industries (company size: 100-500 employees). The finished product inspection was practiced at the 75 percent level by 90 percent of the companies. The in-process inspection was used at the 50 percent level by 95 percent of the companies. The incoming material inspection was used at the 25 percent level by 78 percent of the companies. The partial finished product inspection was used at the lower 25 percent level by 86 percent of the companies.

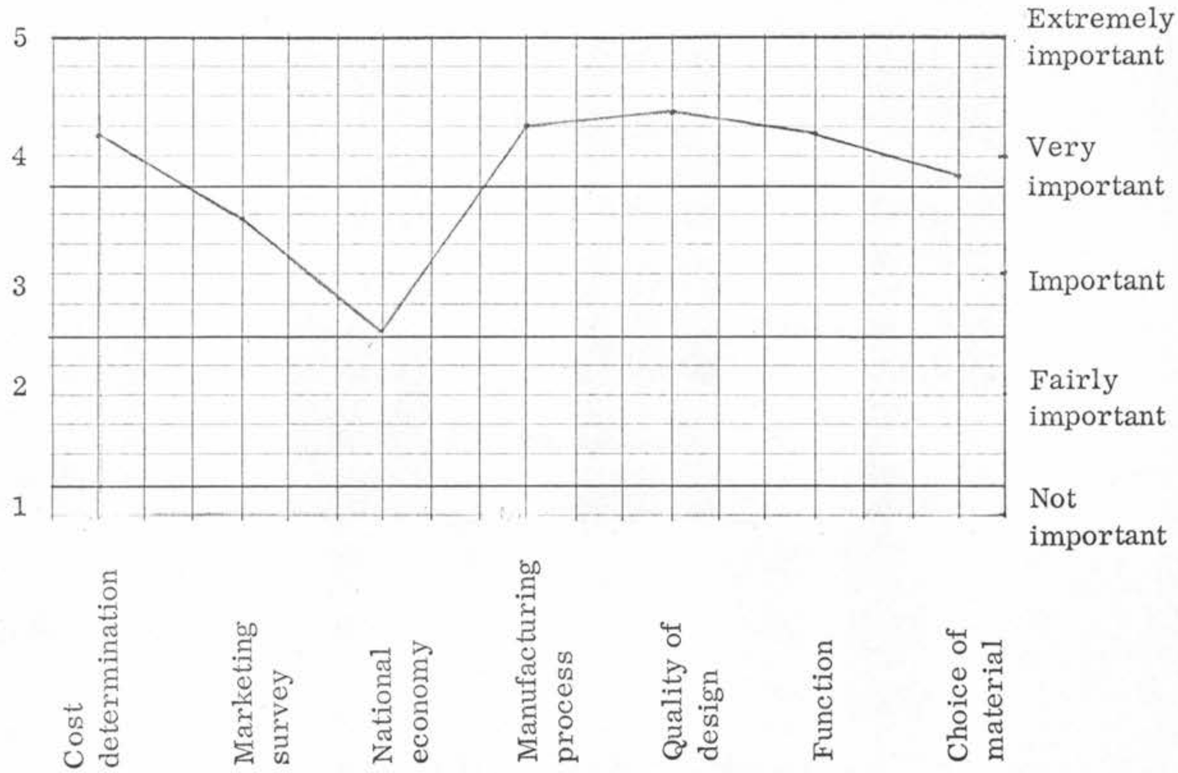

Figure 8. Importance rating of the design and specification criteria of a quality product by Iowa electrical industries (company size: 500 employees or more)

Figure 8 indicated the average opinion on the importance of those factors which determine the quality of a product from the Iowa electrical industries (company size: 500 employees or more). The quality of design and manufacturing process were considered the extremely important factors. The cost determination and function were the second most important factors. The choice of material and marketing survey were the third most important factors. The national economy was the least important factor when compared to the others, in determination of a quality product.

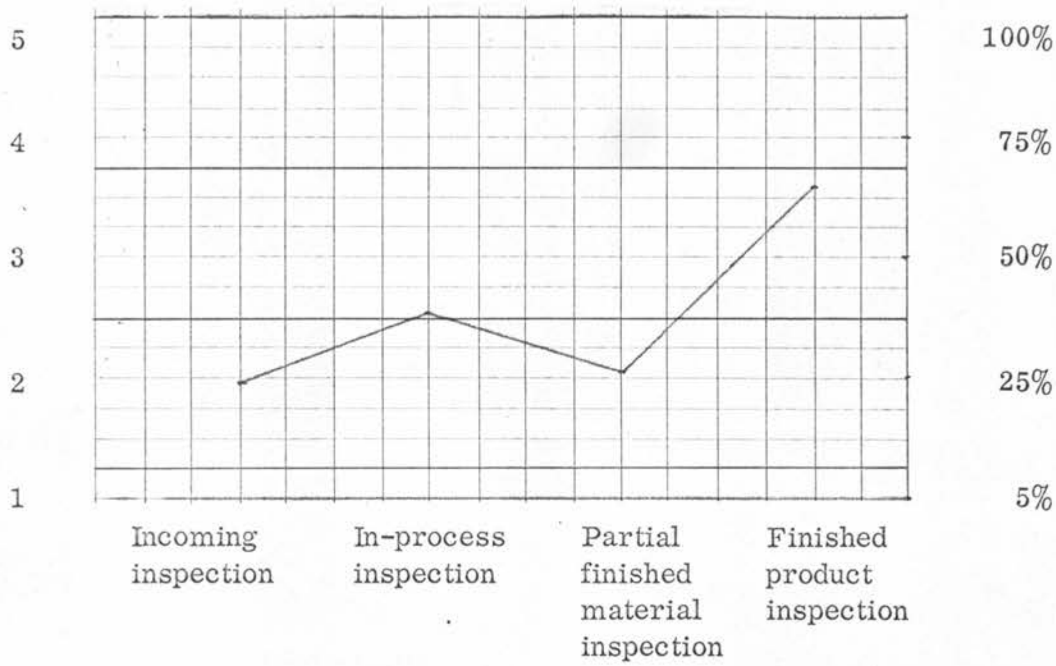

Figure 9. Average practice of quality control methods used by Iowa electrical industries (company size: 500 employees or more)

Figure 9 indicated the average practice of quality control methods by the Iowa electrical industries (company size: 500 employees or more). The finished product inspection was used at the 75 percent level by 86 percent of the companies. The in-process inspection was used at the 50 percent level by 86 percent of the companies. The partial finished product inspection was used in the 25 percent level by 77 percent of the companies. The incoming inspection of material was used in the 25 percent level by 59 percent of the companies.

The result of the third question by both industries, including the different sizes of the companies, was almost unanimous that the principle of "quality control process involves not only the inspection of the product, but the entire cooperation of the organization at all levels, whose determination and constant effort for improvement is more important than what is already in production."

Additional quality determination factors ascertained from industry include meeting the customer demand and meeting government specifications.

B. The Statistical Analysis

The analysis of variance, single classification, was chosen as the best suitable method for analyzing the data collected from the survey of industry since it provides examination into each factor in the problem.

Statistical model:

Y1, Y2, Y3, Y4, Y5, Y6, Y7, Y8, Y9, Y10, Y11, Y12=A(I)+B(J)+E(IJK)

Null Hypotheses (mathematical):

1. A/B, AB=O
2. B/A, AB=O
3. AB/A, B=O

Hypotheses (explanation)

1. There is no significant difference in the means of responses to each of those factors surveyed between the mechanical and electrical industries at the five percent level.

2. There is no significant difference in the means of responses to each of those factors surveyed between the small companies (100-500 employees) and the large companies (500 employees or more) at the five percent level.

3. There is no significant difference in the means of responses to each of those factors surveyed due to the interaction which was contributed by the types of companies and the sizes of companies at the five percent level.

Results of statistical analysis of the survey of industry:

From the statistical analysis, there is no evidence to reject the idea that (1) there is no significant difference in the means of response to each of those factors surveyed between the mechanical and electrical industry at the five percent level, (2) there is no significant difference in the means of response to each of those factors surveyed between the small companies (100-500 employees) and the large companies (500 employees or more) at the five percent level, and (3) there is no significant difference in the means of response to each of those factors surveyed due to the interaction which was contributed by the types of companies and the sizes of companies at the five percent level.

Table 1. Data collected from industry survey

Mechanical industry												Electrical industry											
Company size: 100-500 employees												Company size: 100-500 employees											
Questions												Questions											
Y 1	Y 2	Y 3	Y 4	Y 5	Y 6	Y 7	Y 8	Y 9	Y 10	Y 11	Y 12	Y 1	Y 2	Y 3	Y 4	Y 5	Y 6	Y 7	Y 8	Y 9	Y 10	Y 11	Y 12
4	3	1	3	3	4	3	1	1	1	5	5	3	3	1	3	5	4	3	0	0	0	0	4
3	3	1	5	4	5	3	0	5	2	5	4	4	4	3	5	3	5	3	5	2	3	5	5
4	5	2	4	5	5	3	5	5	3	5	4	4	2	3	5	4	4	4	1	1	2	3	4
3	5	1	1	5	5	5	1	2	2	5	5	4	5	2	5	5	5	5	1	1	1	2	5
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5	4	3	4	3	3	3	1	2	3	5	5	3	2	3	4	4	5	4	1	5	2	4	5
2	3	3	5	5	5	4	5	4	4	3	5	4	3	3	5	5	5	5	0	5	5	5	4
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4	3	2	5	3	3	4	1	1	1	1	5												
4	5	2	3	5	5	3	1	1	1	2	5												

Table 1 (Continued)

Mechanical industry												Electrical industry											
Company size: 500 employees or more												Company size: 500 employees or more											
Questions												Questions											
Y 1	Y 2	Y 3	Y 4	Y 5	Y 6	Y 7	Y 8	Y 9	Y 10	Y 11	Y 12	Y 1	Y 2	Y 3	Y 4	Y 5	Y 6	Y 7	Y 8	Y 9	Y 10	Y 11	Y 12
5	3	4	4	5	5	5	1	0	0	5	4	5	5	2	3	5	4	2	3	3	3	5	5
5	3	3	4	4	4	4	1	2	2	5	4	5	2	1	5	3	2	4	1	1	1	2	5
2	4	4	3	4	4	5	3	4	4	5	5	4	4	4	4	4	4	4	3	3	3	5	4
5	0	0	5	4	2	3	1	2	2	5	5	5	4	3	5	4	4	3	1	1	1	1	4
4	3	3	2	3	5	4	5	5	4	5	5	4	3	3	5	4	5	4	1	4	1	5	5
5	3	3	2	4	5	2	1	2	2	5	5	5	5	5	5	5	5	5	1	1	1	5	4
3	2	3	5	5	5	5	5	4	4	5	5	5	1	1	4	4	5	3	3	5	1	1	5
5	3	3	4	5	3	3	5	1	1	5	5												
5	3	2	4	4	4	4	1	2	2	1	5												
2	5	1	5	5	5	5	1	1	1	4	5												
4	5	1	5	4	5	3	1	3	2	5	5												
5	4	3	5	5	5	5	1	4	4	5	5												
5	5	5	5	5	5	5	5	3	3	5	4												
4	3	3	5	5	5	3	2	2	3	5	5												
4	3	3	5	4	5	4	2	5	2	3	5												

Table 2. Cumulative analysis of variance table

	Source	DF	Sum of squares	Mean square	F
Y1	Type of Co.	1	2.896545410	2.896545410	3.30071604
	Size of Co.	1	2.896545410	2.896545410	3.30071604
	Interaction	1	0.002365112	0.002365112	0.02695128
	Error	56	49.142837524	0.877550662	
Y2	Type of Co.	1	0.379379272	0.379379272	0.2494270751
	Size of Co.	1	0.737991333	0.737991333	0.48520051
	Interaction	1	0.094848633	0.094848633	0.062359277
	Error	56	85.176177979	1.521002769	
Y3	Type of Co.	1	2.081054687	2.081054687	1.442996473
	Size of Co.	1	0.997600098	0.997600098	0.6778646916
	Interaction	1	1.110015869	1.110015869	0.769681351
	Error	56	80.761886597	1.442175865	
Y4	Type of Co.	1	0.213409424	0.213409424	0.205898455
	Size of Co.	1	2.199615479	2.199615479	2.122199762
	Interaction	1	0.497146606	0.497146606	0.479649474
	Error	56	58.042831421	1.036478996	
Y5	Type of Co.	1	0.132995605	0.132995605	0.238056148
	Size of Co.	1	0.132995605	0.132995605	0.238056148
	Interaction	1	0.260681152	0.260681152	0.466607531
	Error	56	31.285705566	0.558673263	
Y6	Type of Co.	1	0.018981934	0.018981934	0.018864849
	Size of Co.	1	1.232772827	1.232772827	1.225168802
	Interaction	1	0.000061035	0.000061035	0.000060658
	Error	56	56.347610474	1.006206521	
Y7	Type of Co.	1	0.191528320	0.191528320	0.1854721255
	Size of Co.	1	0.853591919	0.853591919	0.826601038
	Interaction	1	0.286102295	0.286102295	0.277055637
	Error	56	57.828567505	1.032652855	

Table 2 (Continued)

	Source	DF	Sum of squares	Mean square	F
Y8	Type of Co.	1	4.560409546	4.560409546	2.289313757
	Size of Co.	1	1.084533691	1.084533690	0.544431172
	Interaction	1	0.335784912	0.335784912	0.168562558
	Error	56	111.554763794	1.992049217	
Y9	Type of Co.	1	2.000015259	2.000015259	0.750041844
	Size of Co.	1	2.358642578	2.358642578	0.884532566
	Interaction	1	1.468002319	1.468002319	0.550527383
	Error	56	149.326171875	2.666538239	
Y10	Type of Co.	1	0.000595093	0.000595093	0.00037390046
	Size of Co.	1	5.793685913	5.793685913	3.640207226
	Interaction	1	0.170837402	0.170837402	0.107338153
	Error	56	89.128555298	1.591581345	
Y11	Type of Co.	1	9.359985352	9.359985352	3.225358416
	Size of Co.	1	10.118606567	10.118606567	3.486771780
	Interaction	1	0.335784912	0.335784912	0.115708161
	Error	56	162.511932373	2.901998520	
Y12	Type of Co.	1	0.078186035	0.078186035	0.2546651938
	Size of Co.	1	0.160934448	0.160934448	0.524190827
	Interaction	1	0.142028809	0.142028809	0.462611950
	Error	56	17.192840576	0.307015002	

$F_{1,56}$ 4.02 / 7.12 (From Statistics Table)

C. The Student Survey

There were six answers to the question, "If you are given the chance to choose a method for your project evaluation, which one of the following do you prefer? Please number them according to your preference.", that was surveyed to the students. The undergraduate students were asked to number them according to their preference. The graduate students were asked to pick the best two.

This survey was to determine the extent students should participate in their own project evaluation.

Tables 3, 4, 5, 6, and 7 show their response.

The result of the student survey indicated that students, in general, tend to prefer some participation in their project evaluation. The higher their educational level, the more they tend to prefer to be self-evaluated. This is evidenced in the results of this survey. However, the result and motive behind such a choice is inconclusive. Further studies have to be made for such a determination.

The writer's opinion to this problem is as follows: (1) The upper class students have been exposed to different methods of evaluation in other areas of study, other than grading by the teacher alone. (2) The upper class students are more matured students and feel they can progress and learn by themselves. In addition, they feel confident in their own judgment compared to their teacher counterpart. Thus, they feel they should have a voice in the evaluation of their learning activity.

Table 3. Freshman response to the preference of project evaluation method

Method of project evaluation	Frequency						
	1st choice	2nd choice	3rd choice	4th choice	5th choice	6th choice	no answer
1. Evaluation by teacher alone based on finished product	7	3	3	5	1	0	1
2. Grades given based upon honest self-evaluation	2	1	8	1	8	4	1
3. Grades given based upon elected group of student jury	0	1	4	4	6	3	2
4. Grades given on the average of honest self-evaluation and teacher grade	4	9	1	4	0	0	2
5. Grades given on the average of student jury grade and teacher grade	6	4	5	2	0	1	2
6. No grade at all	0	1	2	1	3	11	2

Total number of students: 20

Results: First preference was evaluation by teacher alone based on finished product.

Second preference was grades given on the average of honest self-evaluation and teacher grade.

Third preference was grades given on the average of student jury and teacher grade.

Table 4. Sophomore response to the preference of project evaluation method

Method of project evaluation	Frequency						
	1st choice	2nd choice	3rd choice	4th choice	5th choice	6th choice	no answer
1. Evaluation by teacher alone based on finished product	9	11	7	4	1	2	4
2. Grades given based upon honest self-evaluation	1	2	4	10	15	3	3
3. Grades given based upon elected group of student jury	3	1	5	9	9	5	6
4. Grades given on the average of honest self-evaluation and teacher grade	9	8	11	3	2	1	4
5. Grades given on the average of student jury grade and teacher grade	11	9	4	5	5	0	4
6. No grade at all	4	2	2	2	1	22	5

Total number of students: 38

Results: First preference was grades given on the average of student jury grade and teacher grade.

Second preference was grades given by teacher alone based on finished product.

Third preference was grades given on the average of self-evaluation and teacher grade.

Table 5. Junior response to the preference of project evaluation method

Method of project evaluation	Frequency						
	1st choice	2nd choice	3rd choice	4th choice	5th choice	6th choice	no answer
1. Evaluation by teacher alone based on finished product	8	9	4	5	4	2	0
2. Grades given based on honest self-evaluation	0	3	9	3	8	4	5
3. Grades given based upon elected group of student jury	0	4	5	8	8	3	4
4. Grades given on the average of honest self-evaluation and teacher grade	15	5	6	5	0	0	1
5. Grades given on the average of student jury grade and teacher grade	7	8	2	5	5	1	4
6. No grade at all	2	1	2	4	3	17	3
Total number of students: 32							

Results: First preference was grades given the average of self-evaluation and teacher grade.

Second preference was evaluation by the teacher alone based on finished product.

Third preference was grades given based on honest self-evaluation.

Table 6. Senior response to the preference of project evaluation method

Method of project evaluation	Frequency						
	1st choice	2nd choice	3rd choice	4th choice	5th choice	6th choice	no answer
1. Evaluation by teacher alone based on finished product	5	8	4	2	1	0	1
2. Grades given based on honest self-evaluation	0	1	4	5	7	1	2
3. Grades given based upon elected group of student jury	0	1	1	6	7	4	1
4. Grades given on the average of honest self-evaluation and teacher grade	12	3	0	4	0	0	3
5. Grades given on the average of student jury grade and teacher grade	1	5	5	2	4	1	3
6. No grade at all	1	1	3	0	0	13	3

Total number of students: 21

Results: First preference was on the average of honest self-evaluation and teacher grade.

Second preference was evaluation by the teacher alone based on finished product.

Third preference was grades given on the average of student jury and teacher grade.

Table 7. Graduate response to the preference of project evaluation method

Method of project evaluation	Choice	
	1st	2nd
1. Evaluation by the teacher alone based on finished product	6	3
2. Grades given based upon honest self-evaluation	0	2
3. Grades given based upon elected group of student jury	0	0
4. Grades given on the average of honest self-evaluation and teacher grade	10	6
5. Grades given on the average of student jury grade and the teacher grade	3	8
6. No grade at all	0	0
Total number of students: 19		

Results: First preference was grades given on the average of honest self-evaluation and teacher grade.

Second preference was grades given on the average of student jury grade and the teacher grade.

D. The Industrial Arts Teacher Survey

Each industrial arts instructor surveyed was given a copy of the rating scale (see next chapter, page 42) based upon quality control processes and procedures. They were given a half hour oral presentation of the idea and the use of this instrument and were asked to check off those items that they deem to be good items for evaluation, items that they think should be deleted, and items they think should be modified.

The result of the industrial arts teachers survey indicated a favorable response to the application of this method for project evaluation. Comments in general, favor to use this guide. Yet comments also indicated this approach to project evaluation might need extra time and additional work for the instructor, especially for large groups. Most of them favorably commented on the learning aspect of this method for project evaluation and indicated they would like to experiment it to their class.

V. DISCUSSION

In general, the results of the survey of industry supported the findings to a great extent of those factors involved in the quality determination of a product that are used in this project evaluation guide.

The result of the graduate student survey supported the idea of projection evaluation based upon the average of self-evaluation and teacher evaluation. The undergraduate student survey also supported the same idea.

The survey of industrial arts instructors also supported the use of this guideline.

However, due to the element of time and financial difficulties, the writer was only able to develop this instrument. Further study by field testing of this approach for industrial arts project evaluation is needed to fully establish its validity as an evaluation technique, though preliminary study indicated favorable response.

Also, the survey of industry was not a representative sampling in that only the wood, electrical, and mechanical industries were examined. Further, only those employing 100 workers or more were selected. A wider survey of industry which will include more industrial classifications than those selected in this study is needed.

Because of the limited sampling, the results of the student survey should not reflect all industrial arts students' opinions relative to selecting self-evaluation as a better approach for industrial arts project evaluation. A further survey which would include high school students is needed for such examination.

This study was limited only to the development of a guideline for industrial arts teachers and students to use for project evaluation. The basis for the development of this guideline was based upon quality control principles, methods, and procedures as used by industry for producing a quality product.

The concept of such an evaluation technique may be controversial for many industrial arts teachers in the future. Its practicality and acceptability by industrial arts teachers cannot be determined at this stage. Further investigation and verification are needed for such examination.

The weaknesses of this evaluation approach are recognized by the writer as time consuming and causing extra work for teachers. In addition, teachers are reluctant to change and have the tendency to follow the traditional system of project evaluation. However, it is the benefits to the student's learning of which the writer is concerned. The strong points of this new approach are: (1) the injection of some learning aspects into the evaluation procedure, and (2) a more objective evaluation.

This study resulted in the development of a project evaluation instrument based on quality control principles and procedures, and is included in this discussion chapter. An abbreviated instruction sheet accompanies the instrument.

It is suggested that this instrument not be used in its entirety at any given time; rather specific portions should be utilized when pertinent to the student activities underway. For example, the items in the project selection stage can be taken up during the first week, and the items in the project design stage can be taken up during the second or third week and so forth . . . depending upon the student's rate of progress.

Instructions on the Use of this Instrument

1. This rating scale is designed to be used by each of the students in the class. The evaluation technique and purposes behind this instrument should be explained to the students by the teacher at the beginning of project construction activity.

2. Each of these 11 major categories is supposed to be evaluated in accordance with the student's progress, with respect to the different phases of his project construction.

3. As the student evaluates himself on each step or process, the teacher also evaluates his student, and the final grade should be the average of the two on the total points.

4. This evaluating instrument only serves as a guide. Not all items in the instrument should be used for the evaluation of all kinds of projects. Certain items in this instrument can be deleted or added upon the teacher's discretion and based upon mutual agreement between the teacher and the student.

5. This instrument is intended to implement some learning activity towards the understanding of industrial processes, materials, and industrial and technical terminology. The rating itself is used as a means to achieve its goal.

6. Grading code:
   1 - Unsatisfactory performance or achievement
   2 - Meets minimum requirements
   3 - Average performance or achievement
   4 - Excellent performance or high achievement
   5 - Outstanding performance or achievement

Industrial Terminology and Equivalent Process	Industrial Arts Project Evaluation	Grade 1	2	3	4	5
	I. Project selection					
Value engineering	1. Cost determination and ability to pay					
Project feasibility study	2. Project usefulness					
Engineering analysis	3. Project selected within his ability					
Time and motion study	4. Time scheduling					
	II. Project design					
Product function	1. Function					
Product structural stability	2. Structure					
Engineering drawing and blueprints	3. Drawing and sketches					
Profit analysis	4. Project cost estimation					
Engineering specification	5. Design specification					
Design modification and replacement	6. Provision for future changes and modification					
Consumer psychology	7. Quality of style					
Engineering design	8. Proportionality					
Manufacturing decision making process	9. Design justification					
Product storage and transportation	10. Reasonable size of project					
Engineering planning	11. Plans step by step procedure					

Industrial Terminology and Equivalent Process	Industrial Arts Project Evaluation	Grade 1	2	3	4	5
Industrial design creativity (pattern)	12. Originality					
Engineering justification	13. Student justification of work plan and design					
	III. <u>Purchasing of material</u>					
Cost reduction analysis	1. Material source investigation					
Purchasing procedure	2. Make out bills of material					
	IV. <u>Incoming material inspection</u>					
Incoming inspection	1. Purchasing the right material					
Quality control methods determination	2. Material inspection methods employed					
Quality determination	3. Percentage of inspection and justification					
Incoming material screening process	4. Basis of rejection					
	V. <u>In-process inspection</u>					
Production efficiency analysis	1. Follows definite work procedures					
Systems engineering	2. Thinks through each procedure					
Line and staff relationship	3. Consultation with instructor when needed					
Production control	4. Machine and instrument set up					
Workman skill proficiency	5. Machine and instrument operation					
Skill and technique	6. Technique and skill in operation					
Skill training	7. Precision of measurement					

Industrial Terminology and Equivalent Process	Industrial Arts Project Evaluation	Grade 1	2	3	4	5
Conformance of engineering specification	8. Tolerance and allowance permitted					
Engineering research	9. Innovation attempted or experimented					
Production efficiency	10. Correct usage of tool and instrument					
Cost reduction	11. Scrap and waste control					
Quality improvement	12. Special process performed					
Mass production control	13. Work interchangebility process provided					
Mass production control	14. Work simplification methods employed					
Occupational knowledge of workers	15. Studies of informational materials regarding work					
Production tryout	16. Experiments performed on scrap					
	VI. <u>Finished product inspection</u>					
Sales engineering	1. Quality of surface finish					
Engineering control	2. Conformity to specifications					
Engineering statistical and projective analysis	3. Operating characteristics a. type of fit b. durability					
Customer feedback	c. reliability and dependability					
Assembly line sampling inspection	4. Quality of assembly					
Sales psychology (engineering harmony)	5. Overall appearance					

Industrial Terminology and Equivalent Process	Industrial Arts Project Evaluation	Grade 1	2	3	4	5
	VII. Human factors					
Industrial organization rule and regulations	1. Neat and organized					
Organizational goal	2. Work cooperation with peers					
Foreman and workman relationship	3. Work cooperation with instructor					
Work satisfaction and happiness	4. Work interest and enthusiasm					
Professional responsibility	5. Work responsibleness					
	VIII. Safe working habits					
Industrial safety	1. Safety work (attitude) behavior in the shop					
Safe equipment maintenance	2. Uses sharp tools and correct instruments at all times					
Safety precaution	3. Machines checked before use					
Industrial safety rule	4. Follows safety instructions					
Accident prevention	5. Consults instructor about machine operation					
Industrial accident statistics	6. Reports hazards to instructor					
Safety guards and hazard avoidance	7. Respects towards instruments and machinery					
Industrial housekeeping	8. Keeps work station clean and free of debris					
Personal protective safety	9. Wears safety glasses at all times					
Operational safety	10. Stays with machine when it is in motion					

Industrial Terminology and Equivalent Process	Industrial Arts Project Evaluation	Grade 1	2	3	4	5
	IX. Appreciation of good design, material, and workmanship					
Industrial display and conferences	1. Introduces good design to class					
Engineering cooperation	2. Compliments on other student's good design					
Industrial morale and human relations	3. Compliments on other student's workmanship					
Improvement of engineering quality	4. Improvement of re-design					
Value analysis	5. Good judgment on purchasing materials					
	X. Attitudes, habits, and peer relations					
Work cooperation	1. Takes suggestions easily					
Work interest	2. Gives suggestions constructively					
Work leadership training	3. Gives suggestions tactfully					
Work cooperation	4. Respects and appreciates others' view point					
Industrial progress and promotion	5. Assumes responsibility					
Work initiative	6. Contributes his share to a job					
Work cooperation	7. Willingness and readiness to help others					
Line authority	8. Acceptance towards dirty or hard work					
Work cooperation	9. Willingness to share tool and instruments					

Industrial Terminology and Equivalent Process	Industrial Arts Project Evaluation	Grade 1	2	3	4	5
	XI. Skill developed, and technical performance					
Skill efficiency	1. Effective use of instrument and machinery					
Engineering experimentation	2. Exposure to the different types of instruments and machinery					
Applied technical development research	3. Number or amount of experiments performed					
Workmanship	4. Workmanship (fast, effective)					
Tool inspection	5. Tools and instruments are kept sharp and in good condition					
Apprentice training and evaluation	6. Knowledge of setting up machines and instruments for work					
Skill and technique development	7. Ability to form judgment through trade and information for work improvement					
Technical communication	8. Ability to read diagrams, drawings and technical symbols					
Use of engineering reference materials	9. Ability to use handbooks and service manuals					
	XII. Related industry and occupational understanding					
Business research	1. Related industrial and occupational research					
Informational resources	2. Reports on field trips, clippings and notes					
Industrial conference	3. Class report and special discussion					
	XIII. Work independently					
Technician and journeyman requirement	1. Initiatives to do more than minimum required work					

VI. SUMMARY

The basic purposes of this study were to make industrial arts project evaluation a continuous process, with more objective evaluation, and the learning process oriented toward the better understanding of industry through the use of industrial terminology and methods. To do this, the study sought to develop a project evaluation guideline for industrial arts teachers and students, based upon quality control principles, methods, and procedures as used by industry. Moreover, use of such evaluation procedure will involve student self-evaluation in addition to teacher evaluation.

A questionnaire was first developed and used to survey Iowa mechanical, electrical and wood industries. All of the 94 companies surveyed employed 100 employees or more. The questionnaire was designed to discover the major factors involved in the determination of a quality product, the quality control methods being practiced, and the basic principle of quality control.

Secondly, an evaluation instrument was developed based upon the results of the survey of industry, and the results of its statistical analysis. Each item in the instrument, a rating scale, was then evaluated by industrial arts teachers who were participating in the 1968 summer industrial education program at Iowa State University, Ames, Iowa. All 32 industrial arts teachers participating in this evaluation had many years of both teaching and industrial experiences.

Thirdly, a student survey was conducted in the industrial education department of Iowa State University, Ames, Iowa, to determine the extent to which students felt they should participate in their own project evaluation. All 130 students surveyed were industrial education majors and all were asked to choose their preferred method for project evaluation (see Appendix, page 56).

To sum up the results of this study concluded as follows:

1. The result of the survey of industry indicated a similar pattern of practice among the companies surveyed regarding quality control principles, methods, and procedures. The factors involved in the determination of a quality product were also generally agreed upon.
2. The result of the survey of industrial arts teachers indicated a favorable response to the concept of project evaluation through the application of this new approach.
3. The result of the student survey supported the idea of student participation in evaluation in that they believed that the final grade should be given upon the average of the student's honest self-evaluation and the teacher's evaluation.

The idea behind this study came from the following theory:

It is generally assumed that there is some subjectivity in any evaluation no matter how objective the instrument of appraisal seems, including the approach derived from this investigation. Moreover, an important adjunct of project evaluation is not the reproduction of the industrial counterpart - a well finished product, but rather it is the amount of learning achieved. Alan R. Pawelek

(11, pages 99-100), Chairman of Industrial Arts, Western Washington College of Education, Bellingham, Washington, strongly emphasized this idea:

> "The premium, then is not upon how well a task has been done, but rather upon what has been done or attempted."

Based upon this concept, the writer developed a new approach for industrial arts project evaluation.

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VII. APPENDIX

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY
Ames, Iowa 50010

DEPARTMENT OF EDUCATION

April 20, 1968

Dear Sir:

I am at present conducting a master's study on product quality analysis and evaluation. The purpose of this study is to relate industrial arts laboratory activities more closely to those employed in industry.

Your company has been selected as one of those whose size and product would include the use of quality control methods. Therefore, your response to the attached questionnaire and your contributing ideas would be greatly appreciated.

Kindly return your answers to me. A self-addressed and stamped envelope is enclosed for your convenience.

Sincerely,

Edison T. W. Wong
Industrial Education
Iowa State University

ETWW:ba
Enc. 1

Product Quality Control Analysis

Q1. Please check the column which best describes the importance an industrialist should attach to the following listed factors of quality control:

The design and specification of a quality product are determined by:

	Extremely important	Very important	Important	Fairly important	Not important
a. cost determination					
b. marketing survey					
c. national economy					
d. manufacturing processes					
e. quality of design					
f. function					
g. choice of material					

Q2. To what extent would you run the following quality control checks on your company product.

	At least 5%	25%	50%	75%	100%
1. incoming material inspection					
2. in-process inspection					
3. partial finished material inspection					
4. finished product inspection					

Q3. How would you react to the following statement:

"Quality control process involves not only the inspection of the product but the entire cooperation of the organization at all levels, whose determination and constant effort for improvement is more important than what is already in production."

Please check the appropriate blank.

Strongly agree	Agree	Disagree	Strongly disagree

Q4. (Optional)
On what criteria do you base your company's product quality control?

STUDENT SURVEY

Methods for Project Evaluation

Please check your status:

Freshman	Senior
Sophomore	Graduate
Junior	Industrial Arts Teacher
	Other

Question:

If you are given a chance to choose your own method for project evaluation, which one of the following methods would you prefer?

A. Evaluation by the teacher alone based on the finished end product.

B. Grades given based upon honest self-evaluation.

C. Grades given based upon elected group of student jury.

D. Grades given on the average of honest self-evaluation and teacher grade.

E. Grades given on the average of student jury grade and teacher grade.